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ABSTRACT

This study was designed to investigate whether problem solving inefficiency in preschool children is the result of subprocess deficiencies in the children's use of logical rules and to assess the influence of 2 mnemonic components (encoding and rehearsal) on problem solving ability. The study subjects, 108 preschool children, were presented with concept discovery problems following rehearsal and coding pretraining in visual and verbal modalities. Results show that visual coding pretraining facilitated solution performance and strategy use on single outcome trials. The failure to find an increase in problem solving efficiency as a function of the coding and rehearsal conditions is discussed. (Author/SE)

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Problem Solving in Preschoolers Following Rehearsal and Coding Pretraining in Visual and Verbal Modalities

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One explanation of the inefficiency observed in young children's problem solving is that it is the result of subprocess deficiencies that underlie the use of logical rules used in problem solving (Eimas, 1970; Gholson, Levine, & Phillips, 1972). This explanation has been shown to be an adequate account of problem-solving deficiencies in grade-school children (Gholson & Danziger, 1975); however, it has not been demonstrated that it can explain deficiencies in preschoolers' problem solving. This study was designed to assess the adequacy of the above explanation as an account of problem-solving behavior in preschool children and to assess the influence of two mnemonic components on problem-solving ability.

Memory has been shown to be an important factor in problem-solving efficiency (cf. Gholson & Danziger, 1975) and there are known developmental differences in memory use. Two aspects of short-term memory (STM) that are known to differ with age are modality of encoding and rehearsal. Developmental research has revealed that young children neither rehearse spontaneously (Flavell, Friedrichs, & Hoyt, 1970) nor code in STM in a manner similar to older children and adults. When presented with visual stimuli, for example, young children apparently tend to code

information in some nonverbal, possibly visual, modality (cf. Hayes & Shultze, 1977); whereas, older children and adults tend to store information in some verbal modality (cf. Conrad, 1972).

The relationship between these two mnemonic subprocesses and problem-solving efficiency has received little attention. Verbal codes, however, may aid subjects in formulating a series of hypothesis for obtaining information relevant to solution (Gibson, 1969) or provide mediators that aid in maintaining information over time (McKinney, 1973). Verbal encoding and cumulative rehearsal also appear to compliment each other. One of the essential characteristics of cumulative rehearsal is its sequential nature (Haith, 1970) and research with adults has shown that a verbal code is better suited for storing sequential information than are nonverbal codes (Paivio, 1970). Therefore, regarding the effects of these two mnemonic components on problem-solving efficiency, it was hypothesized that (a) inducing rehearsal in children who do not rehearse spontaneously would attenuate the loss of solution-related information from memory and thereby facilitate problem-solving efficiency; (b) inducing verbal coding in children would provide mediators that facilitate the formulation of hypothesis statements and the retention of

outcome information, both of which would facilitate problem-solving efficiency; and (c) inducing rehearsal in a verbal modality would be particularly beneficial to problem-solving efficiency because the verbal code has been shown to be ideally suited for storing sequence information and cumulative rehearsal is dependent upon sequential information storage.

Subjects

One-hundred and eight, preschool children (Mean CA = 61.4 months, S.D. = 8.17 months) served as subjects. Children were from middle-class families and attended preschools in the Bangor, Maine area.

Procedure

Subjects were randomly assigned to six conditions. Subjects in the visual coding condition were pretrained to discriminate visually the dimensional values in a problem-solving set. In this condition, two target stimuli representing two values of a stimulus dimension were placed in front of the subject. The subject was then shown each card in a stimulus set constructed from all of the unique combinations of four, bivalued dimensions (color, red and blue; shape, round and square; pattern, dotted and lined; and size, large and small). Subjects were asked to point to the target that was most like the stimulus presented.

The stimulus deck was discriminated in this manner for each of the four dimensions. Subjects in the verbal coding condition were required to describe the stimulus deck verbally. As each card in the stimulus deck was presented, the subject was asked to state verbally which value of a particular dimension the stimulus represented. In the verbal rehearsal condition, subjects were pretrained to rehearse, verbally and cumulatively, the dimensional values of stimuli in the stimulus deck. Subjects in the visual rehearsal condition were pretrained to rehearse, visually and cumulatively, by constructing replicas of stimuli in the stimulus deck. Subjects in two, control conditions (preview and nonpreview) were pretrained to discriminate stimuli that were unrelated to those used in the problem-solving set.

After stimulus pretraining, three concept-discovery problems were presented to subjects in the blank-trials format. Stimuli for these problems were composed of the 16, unique combinations of four, bivalued dimensions mentioned previously. On these problems, subjects selected from sets of orthogonally paired stimuli the figure that they believed contained the experimenter-defined concept. Each problem consisted of 46 trials with feedback on the first and thereafter every fifth trial. On the first and every third outcome trial, subjects in the experimental

conditions were prompted to respond to the positive stimulus in a manner consistent with their pretraining experience. Stimuli were arranged within blank-trial sequences in such a manner that an examination of a subject's left-right pattern of responding revealed information about the subject's use of simple hypotheses and strategies used to test response alternatives.

Results

In two major analyses, ANOVAs revealed a significant main effect for Pretraining Condition. Significant differences were found between conditions in the selection of stimuli with the experimenter-defined concept on outcome trials, F (5,96) = 3.17, $p < .05$. Subjects in the visual coding condition selected significantly ($p < .05$) more correct stimuli on outcome trials than did subjects in either of the control conditions (Table 1). A significant difference, F (5,96) = 3.96, $p < .01$, was also obtained between conditions for the use of hypotheses. Subjects in the visual coding condition used significantly ($p < .05$) more hypotheses than those in either the preview control or verbal rehearsal condition (Table 1). The use of hypotheses was above chance (.5) for subjects in the visual coding condition ($\chi^2 = 12.45$, $p < .01$) and below chance for subjects in the verbal

rehearsal (χ^2= 23.77, $p < .01$) and preview control (χ^2= 10.70, $p < .01$) conditions. Only in the visual coding condition did subjects use hypotheses that were consistent with both positive and negative information from the preceding feedback trial; however, there was no evidence that subjects in any of the conditions used solution-achieving strategies.

Conclusions

The results support a partial extention of hypothesis theory to the preschool level. Subjects in the visual coding condition consistently demonstrated more efficient information use than did subjects in control conditions. Only those subjects in the visual coding condition used simple hypotheses at above chance levels and hypothesis use was consistent with the immediately preceding outcome trial. The more efficient information use following visual coding pretraining may be attributed to mnemonic or perceptual factors that are facilitated by pretraining in a modality in which preschool children tend to encode spontaneously. Visual pretraining may reduce processing demands by (a) inducing a consistent visual coding pattern or (b) heightening attentional or orienting responses to stimulus values (cf. Beilin, 1969).

Although children who were pretrained in the visual coding condition used logical rules for selecting feedback consistent

hypotheses on single outcome trials, they did not use rules that guide solution-achieving behavior over several outcome trials. The failure of the visual coding condition to facilitate solution-achieving behavior may have resulted from a failure to communicate clearly to the child the problem-solving requirement of the criterion task. Another possible explanation of the preschool child's inability to engage in solution-achieving behavior is that these children may have deficiencies in other mnemonic or conceptual processes (cf. Gholson, O'Connor, & Stern, 1976) that limit their use of information to single, outcome trials.

The failure of the rehearsal conditions, particularly verbal, to induce problem-solving efficiency may be attributed to (a) interference with cognitive processes produced by overt verbalization (cf. Denney, 1975) or (b) the induction of a type of rehearsal, e.g., maintenance (cf. Ferguson & Bray, 1976), that was not effective for retaining information over the relatively long retention intervals characteristic of the blank-trial procedure.

Although there was a change in problem-solving efficiency as a function of visual coding pretraining, there was no facilitation that occured as a result of the manipulations that were predicted to facilitate problem solving based upon research with grade-school children. The failure to find an increase in problem-solving efficiency as a function of these manipulations suggests that different kinds of pretraining experiences may be necessary

to facilitate problem-solving efficiency in the preschool child than those that may be required for the grade-school child.

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Table 1

The Mean Percentage of Correct Choices on the Last Seven Outcome Trials and the Mean Number of Hypotheses Used per Problem

Pretraining Condition	Percentage of Correct Choices	Number of Hypotheses Used
Visual Coding Condition	57.1%	5.52
Verbal Coding Condition	55.6%	4.96
Visual Rehearsal Condition	54.8%	4.79
Verbal Rehearsal Condition	52.4%	3.09
Preview Control Condition	47.9%	3.56
Nonpreview Control Condition	45.5%	4.15